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PENSOFT

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New species of tube web spiders of the genus *Ariadna* from South Australia (Araneae, Segestriidae)

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Key Words

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Abstract

Two new species in the tube-web spider genus *Ariadna* Audouin, 1826 (Segestriidae Simon, 1893) are described from South Australia based on morphological features of both males and females. *Ariadna clavata* **sp. n.** and *Ariadna tangara* **sp. n.** are widespread and sympatric on eastern Kangaroo Island, where they are found beneath bark, in borer holes in dead wood, and in short burrows under rocks. They have also been found in south-eastern mainland South Australia and bring the total number of described Australian *Ariadna* to 13 species. We showcase intraspecific variation in both species based on a significant number of specimens, including substantial size variation in females and variations in patterns of leg spination. For male *Ariadna*, we also establish the previously unknown functions of apophyses and spines on the metatarsi and tibiae on the first legs, which are used during mating to clasp the female.

Introduction

Tube web spiders (Segestriidae Simon, 1893) are medium-sized, six-eyed spiders with a distinctive body form; unlike most other spiders the pair of third legs when resting is directed forward, not rearward (e.g. Simon 1893a). Segestriids have simple genitalia and the male pedipalp consists of a simple bulb and embolus whilst the female genitalia lack a sclerotised epigynum.

World-wide four segestriid genera have been described, two of which have been recorded in Australia; *Ariadna* Audouin 1826, represented by eleven Australian species (World Spider Catalog 2018), and *Gippsicola* Hogg 1900, represented by four Australian species (Giroti and Brescovit 2017). *Ariadna* has a worldwide distribution, with species recorded from every continent apart from Antarctica, whilst *Gippsicola* is endemic to Australia (World Spider Catalog 2018).

Of the eleven previously described Australian species of *Ariadna*, males are currently known only for three; *A. kiwirrkurra* Baehr & Whyte, 2016, *A. segmentata* Simon, 1893 and *A. muscosa* Hickman, 1929, while *A. segmentata* and *A. muscosa* are the only species where both males and females are known (Table 1).

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Table 1. Distribution of *Ariadna* species in Australia. (CI – Christmas Island; NSW (LHI) – New South Wales (Lord Howe Island); Qld – Queensland; Tas – Tasmania; Vic – Victoria; WA – Western Australia).

Species	Sexes known	Known distribution
A. burchelli (Hogg, 1900)	F	Vic
A. decatetracantha Main, 1954	F	WA
A. dysderina L. Koch, 1873	F	Qld
A. kiwirrkurra Baehr & Whyte, 2016	M	WA
A. major Hickman, 1929	F	Tas
A. montana Rainbow, 1920	F	NSW (LHI)
A. muscosa Hickman, 1929	M, F	Tas
A. natalis Pocock, 1900	?	CI
A. octospinata (Lamb, 1911)	F	Qld
A. segmentata Simon, 1893	M, F	Tas
A. thyrianthina Simon, 1908	F	WA

The taxonomy of Australian *Ariadna* is at an early stage, with important diagnostic features showing little consensus between the descriptions. Only a single species, *A. kiwirrkurra*, has been described based on modern taxonomic methods (Baehr and Whyte 2016). Many of the historic descriptions overlook diagnostically important features, for example most descriptions of Australian *Ariadna* spp. do not include a description of the preening comb which is an important diagnostic feature. The morphological identification of Australian *Ariadna* based upon the original descriptions is therefore often difficult and current species delimitations may be unreliable. This is confounded by the fact that most descriptions are based upon females, which can display considerable intraspecific variation (Beatty 1970). Additionally, due to the lack of external genitalia, it is not always easy to assess the maturity of a female, resulting in descriptions based upon immature specimens. This is the case, for example, for the type specimen of the Australian segestriid *Gippsicola raleighi* Hogg, 1900 (Giroti and Brescovit 2017).

While the life history of the nocturnal *Ariadna* in Australia is not well understood, it appears that females remain in their retreats most of their lives. It is believed that mature males leave their retreats in search of females (Beatty 1970). The copulatory behaviour of two species from Uruguay was documented by Prandi (1990), neither of these species bore apophyses on leg I of the males and although it has been hypothesised that the apophyses and spines on leg I of some male *Ariadna* species are used during mating (Grismado 2008), their precise function is unknown.

Here we describe two new species of *Ariadna* from South Australia to progress taxonomic research in this poorly studied group in Australia. It is the first Australian study of this genus in which comparatively large number of male and female specimens were available for each species allowing the assessment of intraspecific variation of potentially diagnostic characters. In addition, we explore the functional role of the spines and apophyses on the first leg of males.

Materials and methods

In order to assess the strength of morphological features for specific diagnoses of Australian *Ariadna*, intra- and inter-species variation were analysed using 90 specimens collected on Kangaroo Island, by J. Marsh between 2016 and 2018. South Australian Museum specimens were screened for additional conspecifics of the Kangaroo Island species. Descriptions of external morphological features followed Grismado (2008) and were made from single specimens (holotypes and paratypes). Measurements were taken using the holotypes and paratypes. The pattern of leg spination is described following standard notation for Araneae, with slight modifications as used by Grismado (2008). Where there are special structures, for example the preening combs on the metatarsi of leg IV, or the spines on leg I of some males, these are described separately. Following Grismado (2008) and Giroti and Brescovit (2018) the spination of leg III was not described due to variability. Terminology to describe the structures of the internal genitalia follows Giroti and Brescovit (2018). Dissection of the female genitalia followed methods employed by Platnick et al. (1999) and Grismado (2008). Due to the destructive nature of dissection, descriptions of the internal genitalia of females were based upon conspecific specimens collected from the same locality as the type specimens.

Examination and description of specimens were made using a Zeiss Stemi 305 stereomicroscope. Images were made using a Leica MZ16A microscope and Leica DFC 500 camera with AutoMontage Pro Version 5.2. All measurements of specimens are given in millimetres (mm). Maps were produced by mapping the GPS co-ordinates given on the specimen data labels on to a map of South Australia, GPS co-ordinates were made using projection WGS84. Where there were no co-ordinates on museum specimens Google Earth was used to determine them.

In order to examine the function of the spines and apophyses of leg I of male *Ariadna tangara* sp. n., seven different coupling events were observed, using three males and five females. Females were left in their rearing container and the male introduced to the female. Mating occurred on all occasions apart from one. On two occasions, involving different individuals mating occurred when the female was *in situ* in a tube web. The remaining five occasions occurred where both the male and female were free roaming. Mating images were obtained by placing a mating pair in to 70% ethanol and then in to a freezer. Images were then taken using a Zeiss Stemi 508 stereo microscope with a Zeiss Axiocam 105 colour digital camera.

Abbreviations

AP1 – prolateral apophysis; AP2 – retrolateral apophysis; ap – apical; ALE – anterior lateral eyes; AR – anterior receptaculum, bas – basal; d – dorsal; DL – dorsal lobe; E – embolus; IF – interpuminory fold; Pe – pedipalp; p – prolateral; PME – posterior median eyes; PR – posterior receptaculum; r – retrolateral; RGS – retrolateral grouped spines; UE – uterus externus; v – ventral, T – trachea, VL – ventral lobe.

Collections

CeNak – Centrum für Naturkunde, Universität Hamburg, Germany (Danilo Harms); SAM – South Australian Museum, Adelaide, Australia (no Collections Manager of Arachnology at time of publication; Leslie Chisholm provided curatorial assistance); QM – Queensland Museum, Brisbane, Australia (Robert Raven)

Taxonomy

Family Segestriidae Simon, 1893

Genus *Ariadna* Audouin, 1826

Pylarus Hentz, 1842 (synonymised in Beatty 1970)
Macedonia Hogg, 1900 (synonymised in Rainbow 1911)
Segestriella Purcell, 1904 (synonymised in Beatty 1970).

Remarks. *Ariadna* is distinguished from other segestriid genera by having a straight to slightly recurved posterior eye row (Figs 2A, 3A), a lateral transverse ridge basally on the chelicerae (Fig. 2A; Giroti and Brescovit 2018), a labrum extending past the labium (Figs 2B, 5B; Giroti and Brescovit 2018), and chelicerae with three promarginal and one retromarginal teeth (Beatty 1970). It is distinguished from *Citharoceps* by the lack of stridulatory organ, females lacking a median flap on the interpulmonary fold and by the length of the labium-sternum junction, which is longer than the length of the endite-sternum junction in *Citharoceps* (Giroti and Brescovit 2018).

Note. Holotypes of *A. octospinata*, mature female (QM W2119) and *A. montana*, mature female (SAM NN179) were examined.

Ariadna clavata sp. n.

http://zoobank.org/6C44FD1E-17E3-4F3A-A289-778289106615

Figs 1A–I, 2A–H, 3A–C, 8

Type material. AUSTRALIA: **South Australia:** Holotype: ♂, Tangara Drive, American River, Kangaroo Island, -35.787329S, 137.767213E, 3 June 2017, under bark at 1.5 m height, *Eucalyptus diversifolia* (1 m diameter), J. Marsh (SAM NN29861). Paratypes: 1♀, same data as holotype, except 8 July 2017, observed mating with holotype male in captivity, J. Marsh (SAM NN29862); 1♂, Pelican Lagoon walking trail, American River, Kangaroo Island,-35.796496S, 137.750963E, 2 Nov 2017, under bark *E. diversifolia*, J. Marsh (CeNak ZMH-A0003051); 1♀, Tangara Drive, American River, Kangaroo Island, -35.782887S, 137.771559E, 16 Aug 2017, in tube web at 1 m height, in crevice of bark of *Allocasuarina muelleriana*, J. Marsh (CeNak ZMH-A0003052).

Other material examined. AUSTRALIA: **South Australia: Kangaroo Island:** 1♂, Cannery walking trail, American River, -35.773707S, 137.781111E, 16 Aug 2017 (SAM NN29879); 1♀, Pelican Lagoon Walking Trail, American River, -35.792580S, 137.757909E, 1 Sept 2017 (SAM NN29876); 2♂, same data, except 10 Oct 2017 (SAM NN29881; J. Marsh reference collection, Se092); 4♂, 1♀ same data, except -35.796496S, 137.750963E, 2 Nov 2017 (SAM NN29897, NN29899; J. Marsh reference collection, Se058); 1♂, Tangara Drive, American River, -35.787181S, 137.766994E, 2 June 2017 (SAM NN29865); 1♂, same data, except 3 Jun 2017 (SAM NN29866); 1♂, same data, except 12 Jun 2017 (SAM NN29870); 1♂, 3♀, Antechamber Bay, Chapman River, -35.790736S, 138.065559E, 1 Sept 2017 (SAM NN29892); 2♂, Baudin Conservation Park, Dudley Peninsula, -35.734848S, 137.959212E, 15 Jul 2017 (SAM NN29908); 1♀, Dudley Conservation Park, Dudley West, -35.795318S, 137.850007E, 22 Jun 2017 (SAM NN29911); 1♀, same data, except -35.795452S, 137.860189E (SAM NN29872); 1♂, same data, except -35.795946S, 137.860794E (SAM NN29868); 1♀, Pelican Lagoon Conservation Park, Dudley West, -35.801685S, 137.774214E, 13 Oct 2017 (SAM NN29886); 3♂, 3♀, Simpson Road, Dudley West, -35.823523S, 137.831032E, (SAM NN29910); 2♀, Three Chain Road, MacGillivray, -35.910674S, 137.550490E, 26 Jul 2017 (SAM NN29909, NN29874); 4♀, same data, except 7 Aug 2017 (SAM NN29888, NN29889, NN29890); 4♀, roadside, near Parndana Conservation Park, -35.757187S, 137.307314E, 17 Aug 2017 (SAM NN29891); 1♂, 2♀ roadside, near Parndana Conservation Park, -35.757621S 137.307326E, 10 Aug 2017 (SAM NN29883); 1♀, same data, except -35.756707S, 137.306523E (NN29895); 1♂, same data, except -35.757047S, 137.307237E (SAM NN29893); 1♂, same data, except -35.757131S, 137.307199E (SAM NN29880). **Mount Lofty Ranges:** 1♂, 1♀, Devils Gully Native Forest Reserve, Kersbrook, -34.7555556S, 138.818889E, Oct/ Nov 2000 (SAM, not accessioned); 1♂, Sixth Creek Native Forest Reserve, Forest Range, -34.9002778S, 138.794167E, Oct/ Nov 2000 (SAM, not accessioned). **Fleurieu Peninsula:** 3♂, 2♀, Spring Mount, -35.432222S, 138.523889E Dec/ Jan 2006 (SAM, not accessioned).

Etymology. The specific epithet is an adjective (Latin, *clavata* – striped) referring to the striped abdominal markings of both the male and female.

Diagnosis. Males and females of *A. clavata* sp. n. are distinguished from *A. segmentata* by the curvature of the posterior eye row, which is strongly procurved in *A. segmentata* (Hickman, 1967, fig. 63) and which is slightly recurved in *A. clavata* (Fig. 2C). Males of *A. clavata* differ from *A. segmentata* by the long, curved and distally hooked embolus (Fig. 1G, I), while the embolus of *A. segmentata* is shorter and stouter (Hickman 1967, fig. 65). The pedipalp bulb of *A. clavata* differs from that of *A. muscosa* by being roughly pyramidal in shape, while that of *A. muscosa* is spheroidal (Fig. 1G, I; Hickman 1929, fig. 3a). Males and females of *A. clavata* differ from *A. muscosa* by the number of teeth on the tarsal claws of the first legs; *A. muscosa* has 7 or 8 teeth, with the inferior claw bare, *A. clavata* has 10 or 11 teeth, with a small tooth on the inferior claw (Fig. 2G). Females of *A. clavata* differ from *A. burchelli* by the number of teeth on the chelicerae; *A. burchelli* has one tooth either side of

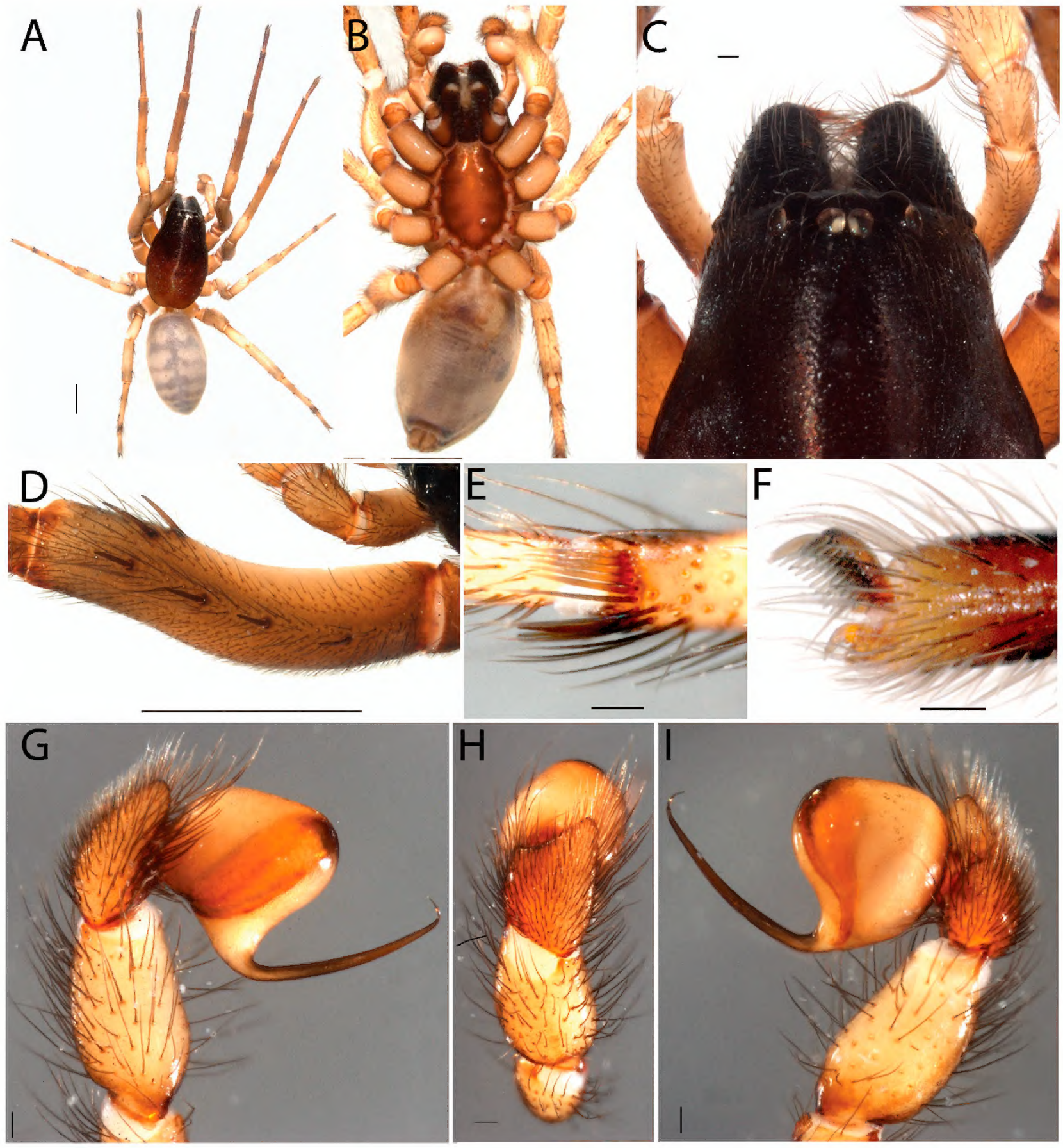

Figure 1. *Ariadna clavata* sp. n., male holotype, from American River, Kangaroo Island (SA; SAM NN29861): **A** habitus, dorsal view **B** habitus, ventral view **C** chelicerae and eyes, dorsal view **D** left leg **I** femur, dorsal view **E** left leg IV, metatarsus preening comb, retrolateral view **F** left leg I, tarsus and tarsal claws, prolateral view **G** palp, prolateral view **H** palp, dorsal view **I** palp, retrolateral view. Scale bars: 1.0 mm (**A, B, D**); 0.1 mm (others).

the fang furrow, *A. clavata* has three teeth on the promargin, one tooth on the retromargin (Fig. 2B, C). *Ariadna clavata* differs from all remaining Australian *Ariadna* by the presence of transverse abdominal markings (Fig. 1A).

Description. Male holotype (SAM NN29861). Carapace length 3.5 mm, dark reddish brown, becoming darker anteriorly, covered with sparse dark setae; sternum brownish yellow, darker at the edges and between coxae; endites dark brown, chelicerae dark brown to black; legs yellowish brown; abdomen length 3.9 mm, dorsally pale yellow with 8 dark transverse bands, connected by triangular extensions at the midpoint (Fig. 1A), ventrally uniform yellow/grey (Fig. 1B). Carapace oval, narrowing anteriorly and apically square; raised anteriorly, highest just behind posterior eye row; lateral margins slightly undulating (Fig. 1A). Fovea an indented pit, with faint dark radial striae extending outwards from fovea. Labium narrowing anteriorly, ¾ the length of maxillae. Chelicerae semi-porrect, with strong lateral ridges dorsally and with basal transverse ridges (Fig. 1C), retromargin with single tooth, promargin with three teeth. Sternum oval with precoxal triangles and with small, rounder intercoxal extensions (Fig. 1B). Posterior eye row slightly recurved (Fig. 1C). Femur I bowed in dorsal view (Fig. 1D). Leg measurements (I–IV): femora 2.74, 2.65, 2.06, 2.28; patellae 1.13, 1.16, 0.99, 1.06; tibiae 2.34, 2.53, 1.50, 1.76; tarsi 2.14, 2.29, 1.64, 1.72; metatarsi 0.97, 0.85, 0.79, 0.80; total 9.32, 9.48, 6.98, 7.62. Spines: Leg I: femur d1-1-1-1, dp2ap (Fig. 1D); tibia dp1-1, p1-1, vp1-1, vp1ap, v1, vr1-1/0-1/0, vr1ap, dv1-1/0; metatarsus vp1-1, vp1ap,

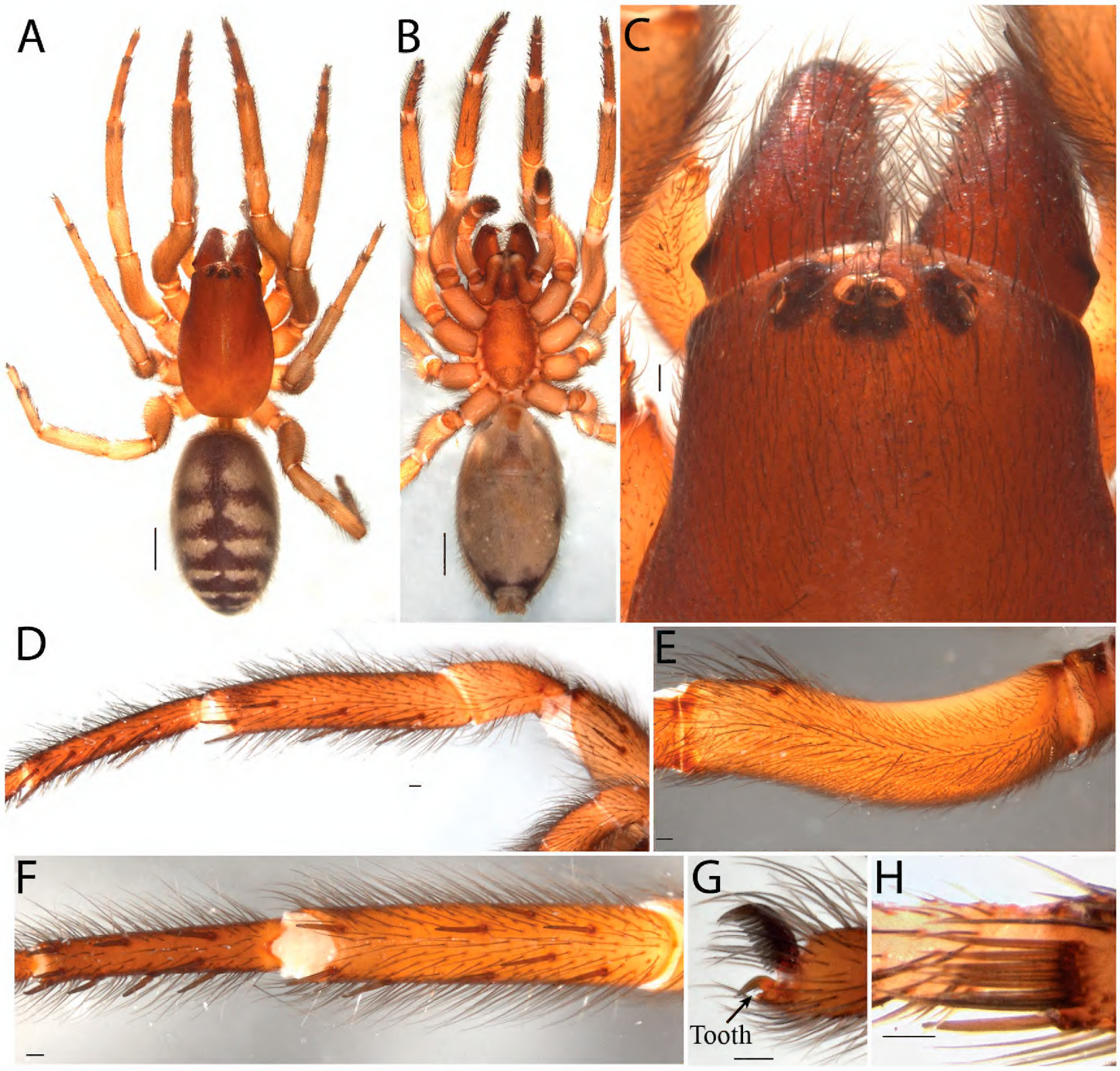

Figure 2. *Ariadna clavata* sp. n., female paratype, from American River, Kangaroo Island (SA; SAM NN29862): **A** habitus, dorsal view **B** habitus, ventral view **C** chelicerae and eyes, dorsal view **D** left leg **I** spines prolateral view (mirrored) **E** femur, dorsal view **F** tibia and metatarsus, spination ventral view **G** tarsus and tarsal claws, prolateral view, arrow indicates inferior claw tooth **H** left leg IV, metatarsus preening comb, retrolateral view (mirrored). Scale bars: 1.0 mm (**A, B, D**); 0.1 mm (others).

v1, vr1-1, vr1ap. Leg II: femur d1-1-1-1-1/0, dp1ap; tibia dp1-1-1, p1, vp1ap, vr1-1-1/0, vr1ap; metatarsus vp1-1, vp1ap, v1, v1ap, vr1-1, vr1ap. Leg IV: femur d1-1-1-1/0, dp1ap, tibia dp1-1/0, vp1, vp1ap, vr1-1, vr1ap, dr1-1; metatarsus dp1, v1, vr1-1, vr2ap, r1-1, retrolateral distal preening comb with five spines (Fig. 1E). Legs I and II tarsal claws with 10 or 11 teeth, one small tooth on inferior claw (Fig. 1F). Legs III and IV tarsal claw with six teeth and inferior claw bare. Tarsi with distal ventral setae, projecting beneath claws (Fig. 1F). Pedipalp femur expanded apically, on the ventral retrolateral edge, so it appears slightly concave ventrally. Pedipalp tibia short, about 1.5 times as long as the cymbium, and swollen in the dorso-ventral plane (Fig. 1G, I). Bulb roughly pyramidal with embolus arising from the ventral point of the pyramid. Embolus long, thin, hooked apically (Fig. 1G–I).

Female paratype (SAM NN29862). Carapace length 3.8 mm, brown, sternum light brown, with darker patches between coxae; endites yellowish brown, chelicerae brown; legs light brown. Abdomen length 4.6 mm, dorsally pale yellow with 8 dark transverse bands, connected by triangular extensions at the midpoint (Fig. 2A). Abdomen ventrally yellowish grey with faint longitudinal darker line centrally (Fig. 2B). Carapace dorsal surface sparsely covered with black setae, with stronger and longer black setae projecting forward from the clypeus (Fig. 2C). Carapace elongated and oval, narrowing anteriorly and apically squared; carapace domed so when viewed laterally highest point is mid-way between fovea and posterior eyes; lateral margin of carapace slightly undulating, fovea a shallow indented pit (Fig. 2A). Sternum oval with precoxal triangles and small, rounder inter-coxal extensions (Fig. 2B). Labium narrowing anteriorly, about ¾ length of maxillae. Posterior eye row slightly recurved, chelicerae hypognathous, covered in strong, long black setae and with basal transverse ridges (Fig. 2C), retromargin with single tooth, promargin with three teeth. Femur I bowed in dorsal view (Fig. 2A,

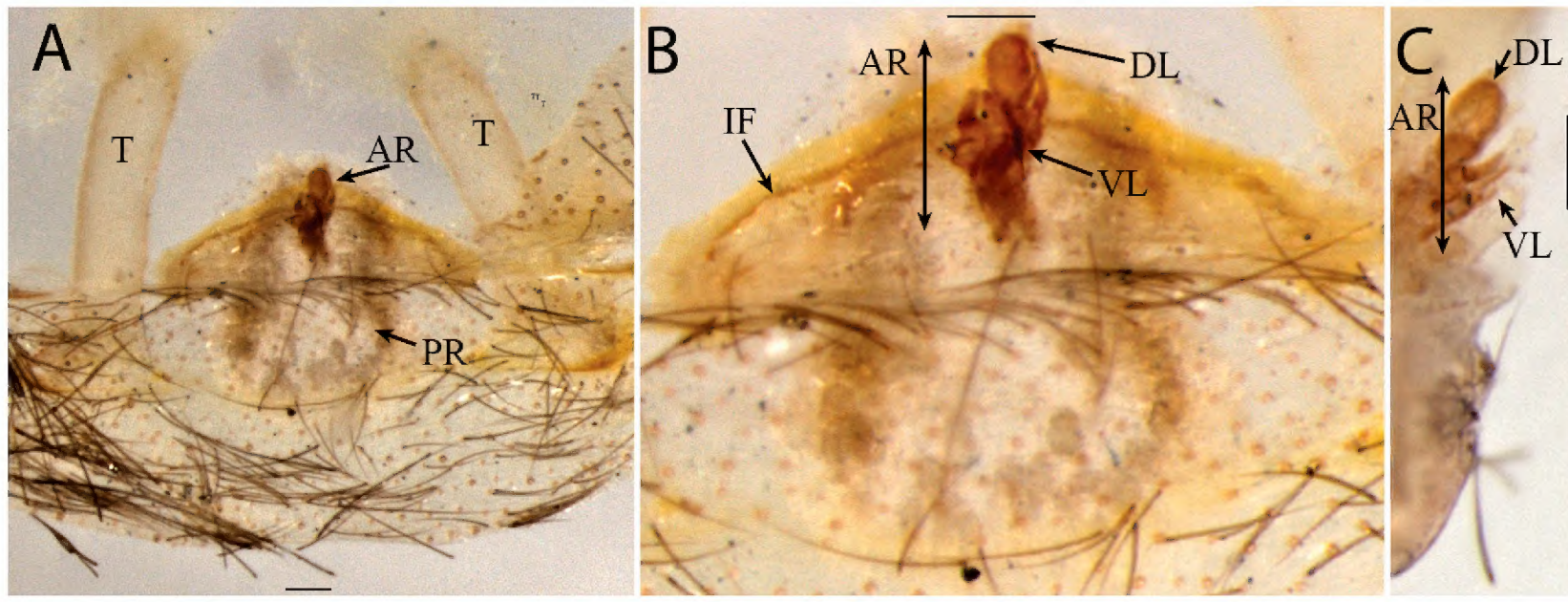

Figure 3. *Ariadna clavata* sp. n., female, D'Estrees Bay, Kangaroo Island (SA; SAM NN29889): **A** internal genitalia, ventral view **B** same, showing structure of AR ventral view **C** same, showing structure of AR, lateral view. Scale bars: 0.1 mm.

E). Leg measurements (I–IV): femora 2.83, 2.59, 1.96, 2.23; patellae 1.21, 1.26, 1.03, 1.25; tibiae 2.08, 2.16, 1.41, 1.8; metatarsi 1.66, 1.76, 1.31, 1.52; tarsi 0.84, 0.89, 0.75, 0.76; total 8.62, 8.67, 6.46, 7.55. Spines: Leg I: femur dp2ap (Fig. 2E); tibia vp1-1-1, vp1ap, v1, vr1-1, vr1ap, v1/0; metatarsus vp1-1-1, vp1ap, v1, v1ap, vr1-1, vr1ap (Fig. 2D–F). Leg II: femur dp1ap; tibia p1, vp1ap, v1-1, v1ap; metatarsus vp1-1-1, vp1ap, v1, v1ap, vr1-1-1/0, vr1ap. Leg IV: femur d1-1, dp1ap, tibia p1, vp1ap, v1, vr1-1, vr1ap; metatarsus v1, vr1-1, vr2ap (1 spine broken), distal retrolateral preening comb with five spines (Fig. 2H). Tarsi with distal ventral hairs, projecting beneath claws, tarsal claws I and II with 11/12 teeth, inferior claw with one small tooth (Fig. 2G). Legs III and IV tarsal claw with six teeth, inferior claw bare. Pedipalps with multiple strong prolateral spines on the tarsus and tibia, and with a single toothless claw. Epigastrium a slightly raised, lightly sclerotized external plate. Internal genitalia: Anterior receptaculum bilobed, dorsal lobe rounded and about 1.5 times as long as ventral lobe. Fig. 3A–C.

Variation (see Suppl. material 1: Table S1): Males (n=21), carapace length: range 2.46–3.64 mm, mean 3.14 mm, standard deviation 0.38 mm. Females (n=23), carapace length: range 2.57–4.34 mm, mean 3.63 mm, standard deviation 0.47 mm. Whilst leg spination showed a large amount of variation, both between and within specimens, some spines showed a higher level of consistency and this was true for both males and females e.g. (1) number of prolateral macrosetae at the apex of the femur I, and (2) the paired macrosetae at the apices of tibiae and metatarsi I and II. The remainder of the spination varied between specimens. The structure of the 'preening' combs on the metatarsus IV was constant in all specimens examined (Figs 1E, 2H).

Distribution. South-eastern South Australia, including the Fleurieu Peninsula, the Mount Lofty Ranges and Kangaroo Island (Fig. 8).

Life history and habitat preferences. The majority of *A. clavata* specimens were collected from within tube webs located beneath rugose bark of older *Eucalyptus* trees. Rather than tree species, the structure of the bark (with specimens found in older, cracked or layered bark), appeared to be of importance. The species appears to be somewhat opportunistic in terms of the location of its retreats, being a variety of holes and crevices, such as borer holes in dead wood (both as standing trees and in logs lying on the ground), in tubular holes in limestone and in burrows in loose soil beneath rocks. The main habitat type was mallee woodland. Specimens were also collected from isolated trees on roadside verges and from a stand of *Pinus radiata* near D'Estrees Bay (Kangaroo Island). Mature males were collected manually throughout autumn, winter and spring (March through to October). Mature females were present all year.

Ariadna tangara sp. n.

http://zoobank.org/D3FE46A5-3843-4796-8F39-AE463BE46BCD

Figs 4A–J, 5A–H, 6A–C, 7A–C, 8

Type material. AUSTRALIA: South Australia: Holotype: ♂, Tangara Drive, American River, Kangaroo Island, -35.787321S, 137.767032E, 12 June 2017, in tube web under bark at 1 m height, *Eucalyptus diversifolia*, J. Marsh (SAM NN29863). Paratypes:1♀, same data as holotype (SAM NN29864); 1♂, American River Reserve, Tangara Drive, American River, Kangaroo Island, -35.788054S, 137.769594E, collected 5 Dec 2017, matured in captivity May 2018, in tube web under bark of *Melaleuca halmaturorum*, J. Marsh (CeNak ZMH-A0003053); 1♀, Tangara Drive, American River, Kangaroo Island, -35.805480S, 137.794437E, 26 Jan 2018, in tube web with spiderlings, in crevice in bark of old apple tree, J. Marsh (CeNak ZMH-A0003054).

Other material examined. AUSTRALIA: **South Australia: Kangaroo Island:** 1♀, Cannery walking trail, American River, -35.773707S, 137.781111E, 23 Jun 2017 (SAM NN29867); 1♀, Pelican Lagoon walking trail, American River, -35.7925800S, 137.757909E, 12 May 2017 (SAM NN29871); 1♀, same data, except 10

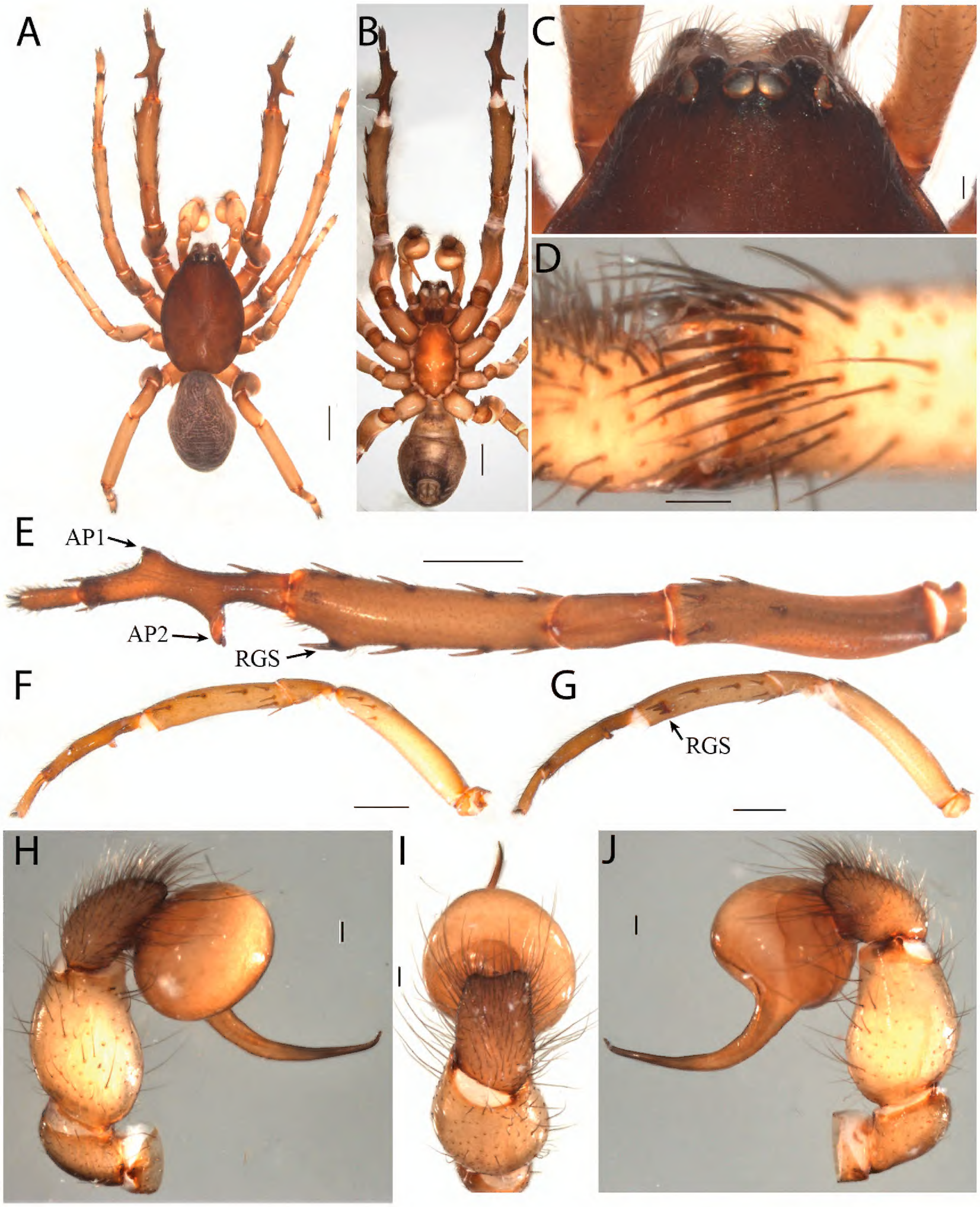

Figure 4. *Ariadna tangara* sp. n., male holotype, from American River, Kangaroo Island (SA; SAM NN29863): **A** habitus, dorsal view **B** habitus, ventral view **C** chelicerae and eyes, dorsal view **D** Left leg IV, metatarsus preening comb, retrolateral view **E** left leg 1 showing AP1, AP2 and RGS, dorsal view **F** same, prolateral view **G** same, showing RGS, retrolateral view **H** palp, prolateral view **I** palp, dorsal view **J** palp, retrolateral view. Scale bars: 1.0 mm (**A, B, E–G**); 0.1 mm (others).

Oct 2017 (SAM NN29882); 1♀, Pelican Lagoon walking Trail, American River, -35.796496S, 137.750963E, 2 Nov 2017 (SAM NN29898); 1♀, Pelican Lagoon Conservation Park, - 35.8016850S, 137.7742141E, 22 Jul 2017 (SAM NN29877); 1♀, American River Reserve, American River, -35.787622S, 137.767650E, 9 Jul 2017 (SAM NN29873); 2♀, Tangara Drive, American River, -35.787181S, 137.766994E, 8 Jul 2017 (SAM NN29869, NN29896); 1♀, same data, except -35.805480S, 137.794437E, 25 Jan 2018 (SAM NN29901); 1♀, same data, except 26 Jan 2018 (J. Marsh research collection, Se064); 1♀, same data, except 19 Jun 2017 (J. Marsh research collection, Se024); 2♀, Antechamber Bay, Chapman River, -35.785218S, 138.066738E, 9 Sept 2017 (SAM NN29884, NN29885); 1♀, Beyeria Conservation Park, Haines, -35.7804109S, 137.590886E, 27 Jul 2016, (SAM NN29875); 1♀, same data, except -35.780488S, 137.590851E, 21 Aug 2017 (SAM NN29894); 1♀, same data, except 10 Dec 2017 (SAM NN29900); 1♂, same data, except coll. 24 Jan 2018, matured in captiv-

ity May 2018 (SAM NN29904); 1♀, Loverings Road, MacGillivray, -35.894155S, 137.569538E, 10 Jan 2018 (SAM NN29902); 1♀, same data, except -35.902882S, 137.572836E, 10 Jan 2017 (SAM NN29907); 1♀, Three Chain Road, MacGillivray, -35.910587S, 137.549724E, 30 Jan 2018 (SAM NN29905); 2♀, same data, except 1 Aug 2018 (SAM NN29906, J. Marsh reference collection, Se091); 1♂, 1♀, same data, except 14 Jun 2018 (J. Marsh research collection, Se079, Se080); 1♀, Three Chain Road, MacGillivray, -35.910674S, 137.550490E, 7 Aug 2017 (SAM NN29887); 1♀, same data, except 9 Aug 2017 (SAM NN29878); 2♀, same data, except 30 Jan 2018 (SAM NN29903). **Fleurieu Peninsula:** 1♂, 1♀, Douglas Scrub, McLaren Flat -34.917740S, 138.494675E, May/ June 1987 (SAM, not accessioned).

Etymology. The specific name "tangara" refers to the type locality, Tangara Drive, where both the male holotype and the female paratype were collected. It is a noun in apposition.

Diagnosis. *Ariadna tangara* differs from *A. clavata*, *A. burchelli*, *A. segmentata* and *A. muscosa* by the lack of abdominal markings. Males of *A. tangara* differ from all other described Australian male *Ariadna* spp. by the presence and shape of apophyses and grouped spines on the metatarsus and tibia I (Fig. 4F). Comparison with *A. octospinata* holotype showed females of *A. tangara* differed by the size of the preening comb on the fourth metatarsi, which in *A. octospinata* is about half the length of the tarsus, but is shorter in *A. tangara* (Fig. 5H) and also by the shape and size of the tooth on the inferior tarsal claw, which is small in *A. tangara* (Fig. 5G) and long and curved in *A. octospinata*. *Ariadna tangara* differ from *A. decatetracantha* by the presence of a small tooth on the inferior claw, which is bare in *A. decatetracantha* and by the number of teeth on the main tarsal claws in females, being four in *A. decatetracantha* and five or six in *A. tangara* (Fig. 5G, Main 1954, plate II, fig. 3), additionally *A. decatetracantha* has seven pairs of spines ventrally on metatarsus I, whereas *A. tangara* has between eight and 12 pairs of spines (Main 1954, plat II, fig. 6). *Ariadna tangara* differs from *A. natalis*, *A. montana* and *A. thyrianthina* by the number of spines on the apex of femur I, bearing five spines in *A. tangara* (Fig. 5F), whilst *A. natalis* has six, *A. montana* two and three spines in *A. thyrianthina*. Additionally, *A. tangara* differs from *A. montana* by the presence of retrolateral and prolateral spines on tibia I, which are absent in *A. montana* (Fig. 5E). *Ariadna tangara* differs from *A. major* by the number of spines on the prolateral edge of femur I (five spines apically in *A. tangara* versus two spines in *A. major*), by the number of teeth on the tarsal claws (eight or nine in *A. major* versus five or six in *A. tangara*), and by the absence of a tooth on the inferior tarsal claw of *A. major* (Fig. 5G).

Description. Male holotype (SAM NN29863). Carapace length 3.5 mm, dark brown, darker anteriorly; faint, dark radial striae extending from the fovea towards the outer edge of the carapace (Fig. 4A). Sternum yellowish brown, with darker patches between coxae; endites and labium yellowish brown, endites white anteriorly; chelicerae brown; legs yellowish brown, leg I becoming darker distally (Fig. 4B). Abdomen length 3.0 mm, dark grey dorsally, lighter grey ventrally, covered with short, black setae. Carapace oval in shape, posteriorly concave, with edges rebordered; surface finely reticulated, with a fine covering of black setae on the pars cephalica; fovea is an indented pit (Fig. 4A). Carapace flattened when viewed laterally, only rising slightly anteriorly. Labium lateral margins rebordered, concave anteriorly, ¾ the length of the endites (Fig. 4B). Sternum oval, with precoxal triangles, anteriorly with neck and concave; coxae I and II swollen at base so that they slightly overhang the sternum (Fig. 4B). Chelicerae hypognathous, laterally with basal transverse ridges (Fig. 4C), retromargin with single tooth, promargin with three teeth. Endites elongate so that when viewed dorsally they extend beyond the chelicerae. Posterior eye row straight, eye group takes up over ¾ of the width of the carapace (Fig. 4C). Leg I: elongated and robust; tarsus is robust and laterally thickened, with a prolateral apophysis (AP1) and an opposing retrolateral apophysis (AP2); tibia with three stout grouped spines (RGS) on prominent base, situated distally on retrolateral surface, and with one prolateral spine opposing the three stout spines (Fig. 4E–G). Leg measurements (I-–IV): femora 3.41, 3.20, 2.27, 2.71; patellae 1.24, 1.01, 1.26, 1.01; tibiae 2.69, 2.68, 1.61, 2.25; metatarsi 2.40, 2.42, 1.58, 1.71; tarsi 0.95, 0.84, 0.89, 0.78; total 10.57 10.38, 7.36, 8.71. Spines: Leg I: femur d1, dp3ap, d2ap; tibia p1-1-1-1, vp2bas, vr2bas, r1-1-1, r3ap (three spines grouped together, on a raised common base; Fig. 4G); metatarsus vp1bas, vp1ap, vr1ap (Fig. 4E–G). Leg II: femur d1-1, dp2ap, d2ap; tibia p1-1-1-1, vr1-1-1, vr2bas, vr2ap, r1-1-1-1; metatarsus p1-1, p1ap, vr1-1, r1/0-1-1-1, r1ap. Leg IV: femur d1/0-1/0-1-1-1-1, tibia vp1ap, v1, metatarsus v1/0, vr1/0, vr2ap, retrolateral distal preening comb with four spines (Fig. 4D). Tarsal claws of legs I and II with 10 teeth, inferior claw with 1 tooth; tarsal claws of legs III and IV with 6 wide teeth, inferior claw with one small tooth. Scopulae ventrally on metatarsi II, III and IV covering entire metatarsus. Scopulae distally on metatarsus of leg I, covering the first third of the ventral surface of the metatarsus. Pedipalp bulb large, rounded, 1.5 width of pedipalp tibia. Embolus long, thin, curved at its apex, back towards the bulb (Fig. 4H, J). Pedipalp tibia basally expanded, pale in colour. Cymbium short, approx. 1.5 times as long as wide, medially indented dorsally (Fig. 4I).

Description. Female paratype (NN29864). Carapace length 4.1 mm, legs, endites and chelicerae golden-brown; carapace with faint darker radial striae extending from fovea; abdomen length 6.6 mm, dorsally pale, mottled grey, ventrally without markings, pale light grey in colour (Fig. 5A). Sternum yellowish brown with darker patches between coxae (Fig. 5B). Lateral margins of abdomen with a longitudinal pale line extending from anterior of the abdomen for ¾ of its length. Carapace with sparse black setae, becoming denser anteriorly; long black setae projecting anteriorly from the clypeus (Fig. 5C). Carapace oval, narrowed at front, apically square; from anterior view clypeus rounded, with its ventral edge indent-

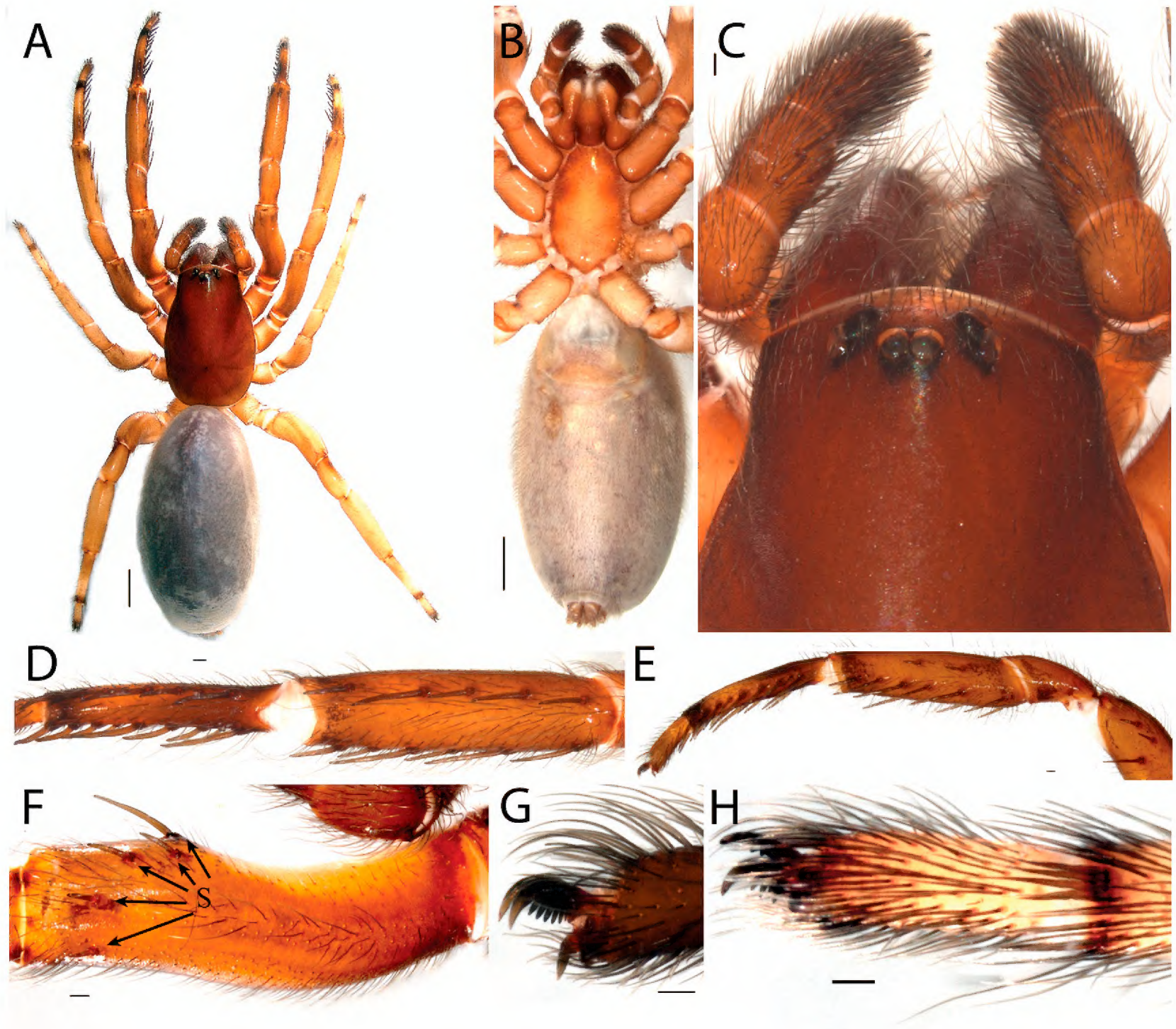

Figure 5. *Ariadna tangara* sp. n., female paratype, from American River, Kangaroo Island (SA; SAM NN29862). **A** habitus dorsal view **B** ventral view **C** chelicerae and eyes, dorsal view **D** tibia and metatarsus, ventral view **E** left leg I, spines, prolateral view (mirrored) **F** femur, dorsal view, s denotes apical spines **G** tarsus and tarsal claws, prolateral view **H** left leg IV, metatarsus preening comb, retrolateral view (mirrored). Scale bars: 1.0 mm (**A, B, D**); 0.1 mm (others).

ed medially in a ”U” shape; caput gently raised; fovea a shallow indented pit (Fig. 5A, C). Sternum oval, anteriorly concave, posteriorly forming a broad point between the fourth coxae; sternum with precoxal triangles; coxae I and II basally swollen so the ventral edges overhang the sternum (Fig 5B). Labium ¾ length of maxillae, widest at midpoint. Posterior eye row slightly procurved, chelicerae hypognathous, laterally with basal transverse ridges, anterior surface of chelicerae with long, fine, pale-brown setae and thicker black setae (Fig. 5C). Retromargin with single tooth, promargin with 3 teeth. Legs I and II ventrally and prolaterally covered with long, fine, pale-brown setae (Fig 5D). Femur I bowed (Fig. 5A, F). Leg measurements (I–IV): femora: 2.93, 2.60, 1.91, 2.35; patellae 1.37, 1.37, 1.04, 1.42; tibiae 2.15, 2.19, 1.44, 2.17; metatarsi 1.81, 1.86, 1.39, 1.35; tarsi 0.62, 0.57, 0.63, 0.68; total 8.88, 8.59, 6.41, 7.97. Spines: Leg I: femur dp3ap, d2ap; tibia p1-1, v2/1-2-2-2-2/1-2 (5 paired spines ventrally, 2/1 additional unpaired prolateral spines), r1/0; metatarsus v2-2-2-2-2-2-2-2-1-1/0 (Fig. 5D–F). Leg II: femur dp2ap; tibia p1-1, v2-2-2-2-1; metatarsus v 2-2-2-1-2-2-2-2. Leg IV: metatarsus vr1ap, distal retrolateral preening comb with four spines (Fig. 5H). Tarsal claws of legs I and II with six teeth, a minute tooth on the inferior claw (Fig. 5G). Tarsal claws of legs III and IV with three or four uneven teeth, inferior with a very minute tooth. Epigastrium a raised, lightly sclerotised mound (Fig. 5B). Internal genitalia: anterior receptaculum bilobed, ventral lobe about 1.25 times longer than dorsal lobe. Fig. 6A–C.

Variation (see Suppl. material 1: Table S1): Males (n=4), carapace length: range 3.47–3.93 mm, mean 3.72 mm, standard deviation 0.23 mm. Females (n=25), carapace length: range 4.06–6.96 mm, mean 4.82 mm, standard deviation 0.58 mm. Whilst leg spination did vary between males, some spines, or combination of spines remained constant. Spines that were constant in the specimens examined included the paired spines basally on the prolateral and retrolateral sides of the tibia of legs I and II (Fig. 4F, G), and two apical spines on metatarsus I (Fig. 4E). The grouped retrolateral spines (RGS) on the tibia, and the apophyses (AP1, AP2) on metatarsus I, showed no variation in the males examined (Fig. 4E, G).

Spination of females varied, both between specimens and between the left and right legs of individuals. Prolat-

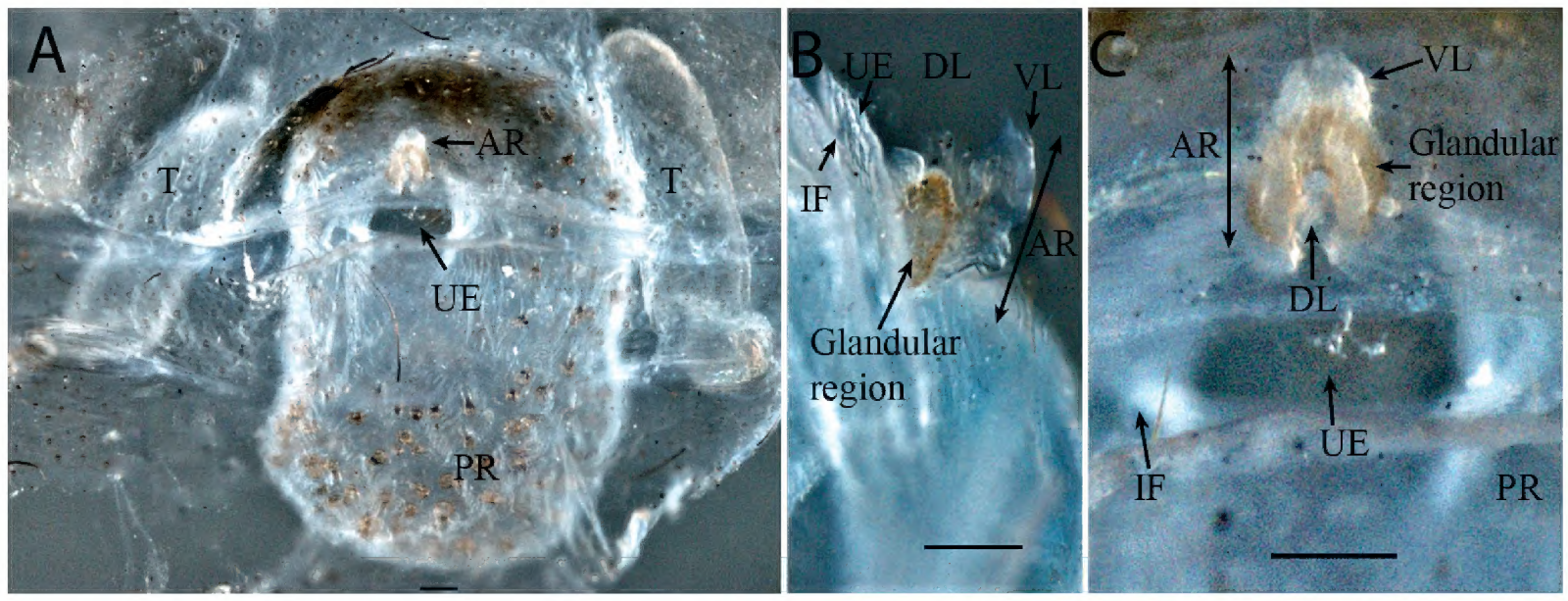

Figure 6. *Ariadna tangara* sp. n., female, American River, Kangaroo Island (SA; SAM NN29869). **A** internal genitalia, ventral view **B** same, showing structure of AR, lateral view **C** same, showing structure of AR, ventral view. Scale bars: 0.1 mm.

Figure 7. *Ariadna tangara* sp. n.. male and female, D'Estrees Bay, Kangaroo Island (SA, J. Marsh reference collection, Se079, Se080). **A** female (below) mating with male (above) **B** male apophyses hooked on to female carapace and legs, dorsal view **C** detail of the embolus entering the gonopore.

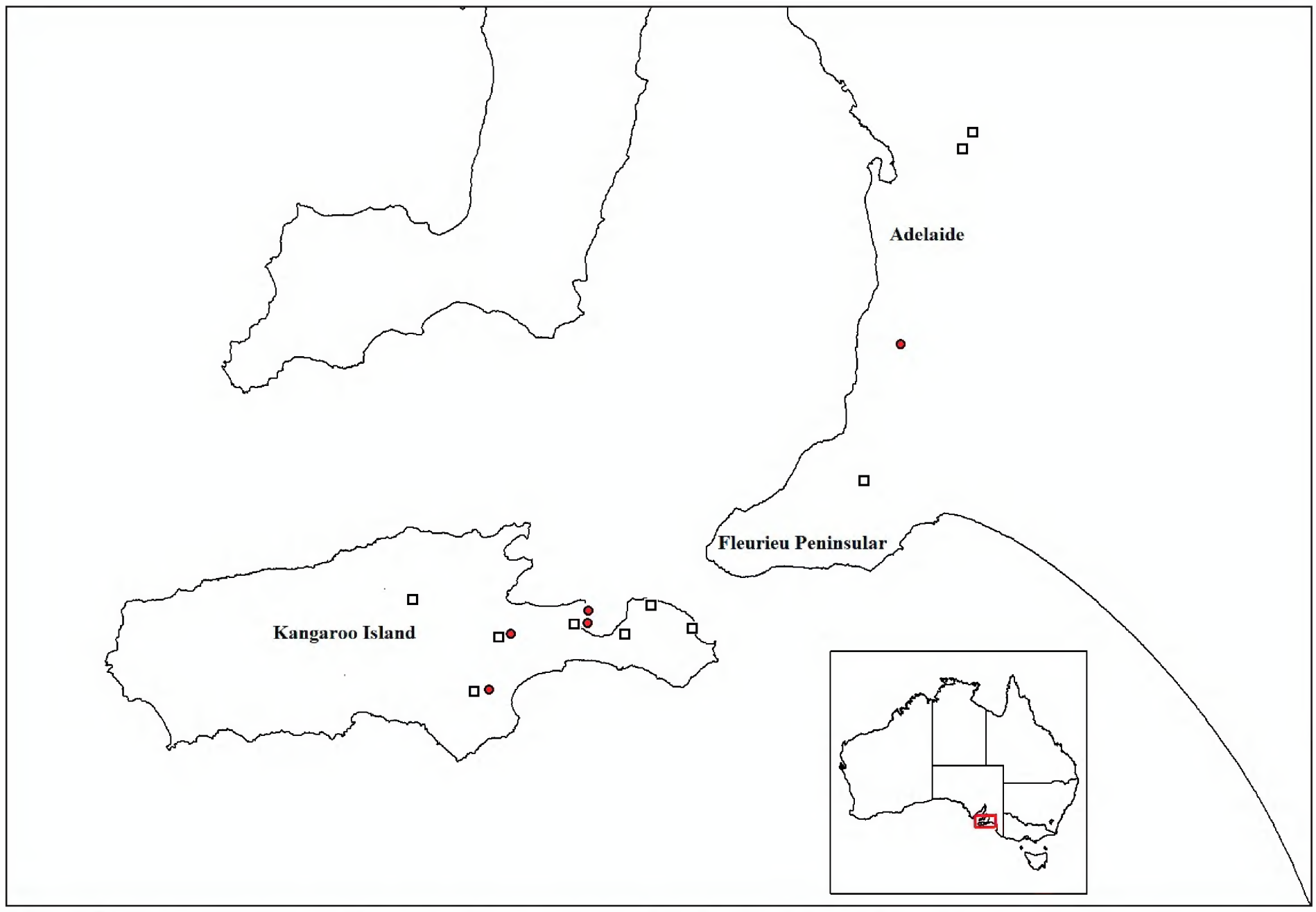

Figure 8. Distribution map for males of *Ariadna tangara* sp. n., (filled circles) and *Ariadna clavata* sp. n., (hollow squares).

eral and retrolateral spines were present on tibia I of all specimens. The number of spines per specimen varied between two or three prolateral spines, and one or two retrolateral spines. The number of paired ventral spines on tibia I varied between seven and five pairs per specimen. The ventral paired spines on metatarsi I varied between eight and eleven pairs per specimen. The prolateral spines at the apex of femur I was constant (Figs 4E, 5F). The structure of the preening comb showed very little variation (Figs 4D, 5H).

Distribution. South-eastern South Australia, including the Fleurieu Peninsula and Kangaroo Island (Fig. 8).

Life history and habitat preferences. *Ariadna tangara* has a similar distribution to, and was often found sympatric with *A. clavata*. Both species were mainly collected from within tube webs located beneath rugose or cracked bark of older trees. As with *A. clavata*, tree species appeared to be less important than the structure of the bark. Distribution was highly patchy. Hundreds of specimens may be present on one tree, while the species was hard to find on other trees in the locality. Tube-webs of juveniles were often found grouped around those of mature females, with sometimes hundreds of webs belonging to specimens of different ages (as discerned by varying entrance size and specimen size) on a particular tree. Despite a concerted effort to collect males, only two mature males were collected manually, both in winter (June). One of the mature males was collected from under bark in a tube web adjacent to a female web. During captivity, two males matured in May (both collected in December the previous year) constructed tube-webs similar to those of the females, but with less dense weaving. Mature females were collected across the year. Females with eggs or with spiderlings were collected in December through to February. Eggs were not enclosed in an egg sac, but located on the bottom of a thick tube-web, with the female *in situ*. Once emerged, the spiderlings remain with the female prior to dispersing.

Function of the modified first legs in males. In captivity, *Ariadna tangara* males employed two distinct coupling tactics, depending on whether the female was in a tubular retreat or not. Where the female was free roaming (n=5), the male approached the female whereupon she adopted a defensive posture with fore legs raised. He hooked the front coxae/trochanters with AP2, the RGS hooked on to the female's front femora and with AP2 wedged against the lateral edges of the female's carapace (n=7) (Fig. 7A, B). The male then turned the female on to her back and mated with her in that position (n=5) (Fig. 7A, C). Where the female was occupying a tubular retreat (n=2), the male placed his front legs on the entrance of the retreat and vibrated his body rapidly (n=2). The female emerged slowly, with front legs raised. Once the female's front legs were out of the retreat the male gripped her front coxae/trochanters as described above, but mated with the female upright, whilst her abdomen was still in the retreat. Most often the male mated with both emboli inserted in the epigyne concurrently.

Discussion

As a genus, there has been little agreement on species-delimiting traits and thus classification of various *Ariadna* spp. is fraught with complications and challenges for morphologically based taxonomic identification. This is especially so for females, which form the majority of the currently described Australian *Ariadna* (Table 1). In agreement with the findings of Beatty (1970) and Grismado (2008) we found intra-specific variation in spination of females to be high, both in different individuals of the same species and for legs on different sides of the same specimen. We also found variation between females of different species to be relatively low, considering the amounts of intra-species variation. The type specimen of *A. octospinata* was morphologically similar to the type specimen of *A. tangara* sp. n., with the exception of the structure of the preening comb on the fourth metatarsus, which was significantly longer, relative to the tarsus, in *A. octospinata*. On the other hand, the type specimen of *A. montana* was morphologically distinct to that of *A. tangara* sp. n. for most of the key diagnostic macrosetal groups used here, namely the pattern of spination dorsally on femur I, the presence/absence of retrolateral spines on tibia I and the structure of the preening comb on metatarsi IV. The number of paired spines ventrally on tibiae and metatarsi I for the type specimens of *A. octospinata*, *A. montana* and *A. tangara* differed little and were within the range of intra-species variation we recorded for these spines. These ventral paired spines have been identified as being useful diagnostically for American *Ariadna* (Beatty 1970), however our findings suggest caution is required when using them diagnostically, especially when a small number of specimens are examined, and where intra-species variation cannot be adequately assessed. We showed significant differences between the internal genitalia of females of *A. clavata* and *A. tangara*, particularly in the structure of the anterior receptacula. These findings support those of Grismado (2008) and Giroti and Brescovit (2018), that the structure of the anterior receptaculum is diagnostically important and give further strength to the usefulness of the character taxonomically. This highlights the importance of the inclusion of descriptions on internal female genitalia in future taxonomic work on Australian *Ariadna*.

Male *Ariadna* examined in this study proved to be more taxonomically informative than females. There was little variation in leg spination of conspecific males for some key spine groups of the tibia and metatarsus of the first leg, however, further research using a wider range of specimens from different localities or populations is needed to characterise the geographical or population-level variation, and ultimately the variation that could be expected from a range of species across a known geographical range. Male pedipalps differed between species, both in the shape of the embolus, the shape of the pedipalp bulb and the shape and relative size of the pedipalp tibia and femur. For both males and females, the number of teeth on the tarsal claws and the presence and shape of the tooth on the inferior claw; the number of spines and their arrangement in the preening comb of metatarsi IV; and the curvature of the eyes did not vary, outside of a defined range, and are therefore strong characters for species identification.

In agreement with the hypothesis of Grismado (2008), we showed that the apophyses of the metatarsus of leg I and the retrolateral grouped spines of the tibia of leg I in males, had an important function in gripping the female during mating. The apophyses and opposing spines effectively held the female's carapace and prevented her from moving away from the male, or from killing him. This is an important finding as, excepting the study by Prandi (1990), there has been little documentation of the mating behaviour of *Ariadna*, and the function of the apophyses, which are found on males of many species of *Ariadna* internationally (for example Beatty 1970, Grismado 2008, Giroti and Brescovit 2018), was unknown.

As discussed in the introduction, the taxonomy of Australian *Ariadna* is in an early state, with many historical taxonomic papers missing out crucial diagnostic features. The findings from this work point towards the necessity of a revision of the genus in Australia and the redescriptions of species using modern taxonomic techniques, including the internal genital structures of females.

Acknowledgements

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Supplementary material 1

Table S1

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Data type: (Raw data: Carapace length (mm), number of teeth on main tarsal claws of leg I, spines on leg I and the number of spines in the preening comb on metatarsus IV for Ariadna clavata sp. n. and Ariadna tangara sp. n.)

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